An Expanded TRMM-CloudSat (2006-2014) and GPM-CloudSat (2014-near current) Coincidence Dataset

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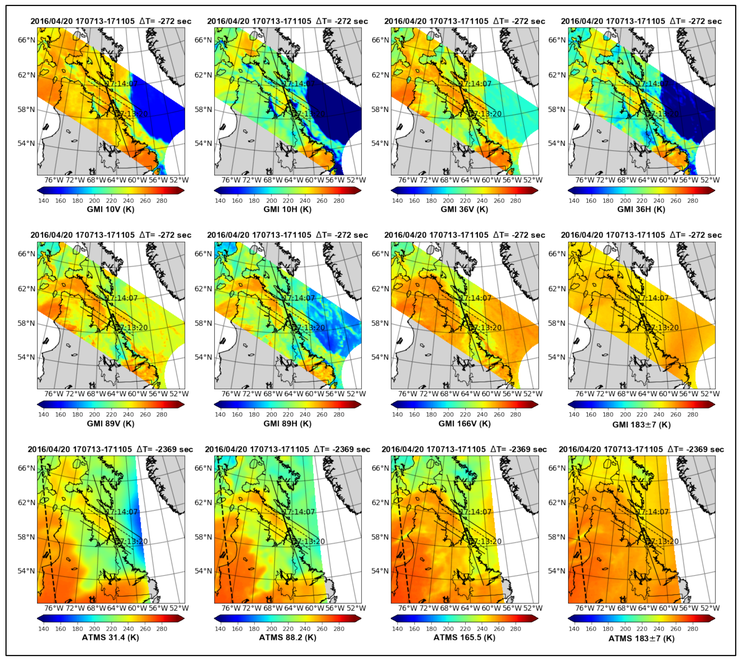
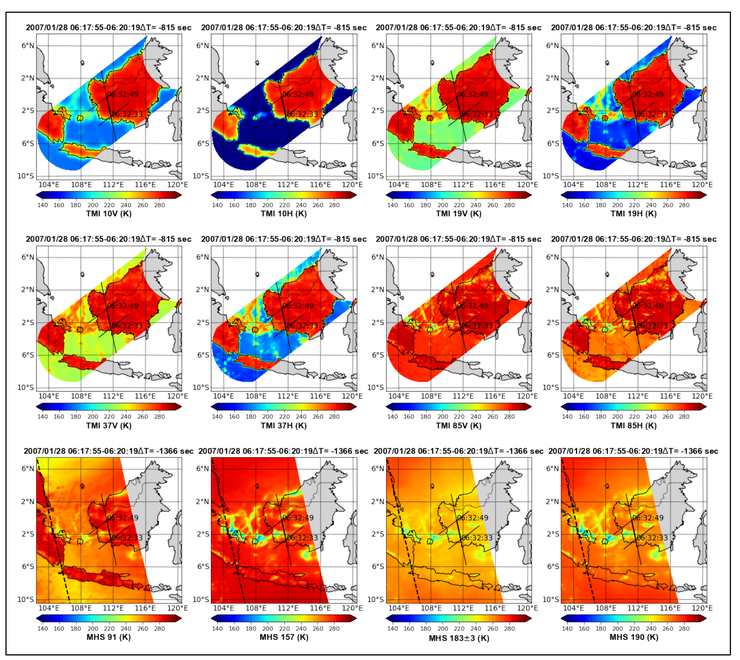
Multi-frequency Radar Profiling of Clouds

With their sensitivity to clouds as low as ≈15 dB, the Ku/Ka-band GPM-DPR radar provides water content profiles to the surface through all but the heaviest precipitation and the light rain and snowfall. The low-end sensitivity implies that a significant fraction of solid-phase (snow) precipitation and sub-1 mm/hr rainfall remains unobserved. Additional observations are needed to indicate the presence or absence of snow and light rain, to further assess the capability of GMI and other sensors for cold-season precipitation, and related validation studies. More recently, the published NASA Decadal Survey for Earth Observations from Space (ESAS-2017) addresses measurements needed to address open questions or the Weather and Air Quality science such as, "*What processes determine cloud microphysical properties and their connections to aerosols and precipitation?*". While studies are under discussion for the instrument suite needed to address these questions, it is envisioned that a W-band (94 GHz) radar may be needed to fill key requirements. Another where additional radar frequency could benefit is in TRMM and GPM algorithm development. The latest version of radar-only and combined radar-radiometer data products are processed across both the TRMM (PR+TMI) and GPM (DPR+GMI) observational period. To enable long-term studies (20+ years), the TRMM and GPM products should be consistent as possible. A more complete vertical structure, including any portions of the clouds that extend below the DPR (PR) sensitivity, provide a more realistic cloud profile for radar and radiative transfer simulations that cover the full GMI 10-183 GHz channels range, to benefit GPM combined-sensor precipitation retrieval algorithms.





An Expanded TRMM-GPM-CloudSat Coincidence Dataset

The orbit ground track of the Tropical Rainfall Measuring Mission (TRMM) and the Global Precipitation Measurement (GPM) core satellite routinely intersects the tracks of other sun-synchronous satellites. Of particular interest to the precipitation measurement and modeling community are the intersections (coincidences) with the 94-GHz (W-band) CloudSat profiling radar (CPR). CloudSat was launched in June 2006 and despite intermittent operations since 2011, is still collecting intermittent science quality data. For the TRMM era, this provides joint Ku-W radar profiles and products and 9-channel (10-85 GHz) TMI observations. For GPM, a unique dataset (2BCSATGPM), consisting of Ku/Ka/W radar profiles and 13-channel (10-183 GHz) GMI observations, together with several GPM and CloudSat precipitation products, has been available at PPS since 2016. This poster presents an expanded dataset, which has been completed for both TRMM and GPM through late 2016 (will be extended to current when many CloudSat data products are up to date). The expanded dataset includes many more products from CloudSat, organized into a more descriptive group file content. Additional nearby-time MW sounder data from the afternoon local time operational sounders (NOAA-18 MHS for the TRMM era, and Suomi NPP ATMS for the GPM era) are included when these satellite tracks also cover the coincidence region. The TRMM-GPM overlap period extends from 2014/03/10-2014/09/01.

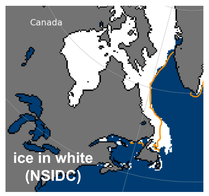
Dataset Name	Satellite or Source	Description	Date Range Available
2A.GPM.DPR (GPM) 2A.TRMM.PR (TRMM)	GPM/TRMM	DPR or PR Ku-only and Ku/Ka-band (GPM) radar reflectivity profile and precipitation retrievals	2006/06/15-current (2006/06/15 is the start of the CloudSat data)
2B.GPM.DPRGMI.CORRA 2B.TRMM.PRTMI.CORRA	GPM/TRMM	DPR+GMI (PR+TMI) combined radar+radiometer precipitation profiling algorithm	
1C.GPM.GMI.XCAL 1C.TRMM.TMI.XCAL	GPM/TRMM	GMI (13-channel) or TMI (9-channel) Level 1C brightness temperatures	
2A.GPM.GMI.GPROF 2A.TRMM.TMI.GPROF	GPM/TRMM	GPROF precipitation profiling algorithm for GMI or TMI	
1C.NOAA19.MHS.XCAL	NOAA-19	MHS (5-channel) Level 1C brightness temperatures	2006/06/15-2012/12/31 (TRMM era only)
2A.NOAA19.MHS.GPROF	NOAA-19	GPROF precipitation profiling algorithm for MHS	
1C.NPP.ATMS.XCAL	Suomi NPP	ATMS (9-channel) Level 1C brightness temperatures	2014/03/10-current (GPM era only)
2A.NPP.ATMS.GPROF	Suomi NPP	GPROF precipitation profiling algorithm for ATMS	

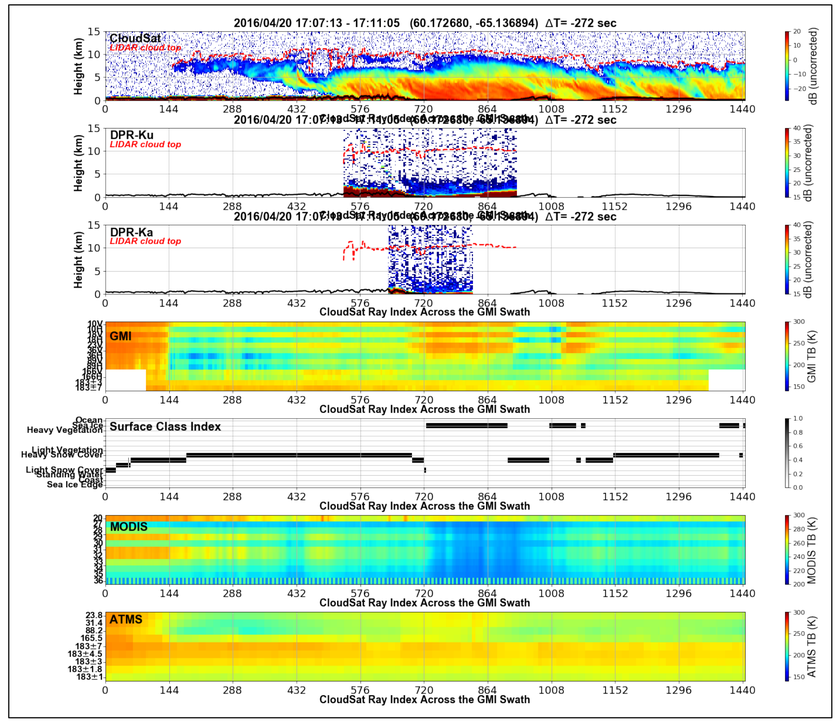
Dataset Name	Satellite or Source	Description	Date Range Available
2B-GEOPROF	CloudSat	CloudSat Profiling Radar (CPR) vertical reflectivity profile	2006/06/15-2016/09/01 Current period of complete coverage of Release 5 (R05) data products Dataset will be extended to more current once CloudSat R05 data products are produced
2B-GEOPROF-LIDAR	CloudSat+ CALIPSO	CPR+CALIOP vertical cloud layer detection profile	
ECMWF-AUX	ECMWF	ECMWF forecast analysis interpolated to each vertical CloudSat bin	
MODIS-AUX	Aqua	MODIS 1-km channels 20 and 27-36	
2C-SNOW-PROFILE	CloudSat	CPR snowfall profile	
2C-RAIN-PROFILE	CloudSat	CPR precipitation profile	
2C-PRECIP-COLUMN	CloudSat	CPR near-surface precipitation average	
2B-CWC-RO	Cloudsat	CPR Radar-Only Cloud Water Content Product	
2B-CWC-RVOD	CloudSat+ Aqua	CPR+MODIS Radar-Visible Optical Depth Cloud Water Content Product	
2C-ICE	CloudSat+ CALIPSO	CPR+CALIOP ice cloud water content, effective radius and extinction coefficient for identified ice clouds	
2B-CLDCLASS	CloudSat	CPR cloud type classification	

20 April 2016 1707 UTC
Orbits GPM 12183 CloudSat 53090 NPP 23215
Labrador Sea Area

The figure panels to the left show the GPM overpass over the Labrador Sea (60N 65W), an area associated with shallow freezing levels and periods of ice cover. This ascending CloudSat overpass on this day passed over ice cover, vegetated land and snow cover, challenging conditions for snowfall detection. The scattering signal at 89 GHz and above is weak for dry snow (DPR senses only the lower 3-km, up to 20-25 dB max, nearest to nadir), and similar to the scattering from snow cover, and the thermal emission signal from the background and atmosphere is also radiometrically cold. The CloudSat W-band profile (right panels) shows that owing to the wind speed profile (provided in the coincidence dataset) the snowfall profile is slanted. This has implications for radar precipitation profiling when making assumptions on the vertical nature of the path-integrated attenuation (here, the attenuation occurring across each bin is offset from the bin(s) above and below).

Note that the 2B-GEOPROF-LIDAR data, which incorporates both CALIPSO and CloudSat data to provide an indication of multi-level clouds, shows the top-most cloud layer is near 10-km across most of the cross section, with CloudSat tops 2-3 km lower than this, and DPR cloud top is near 3-km.

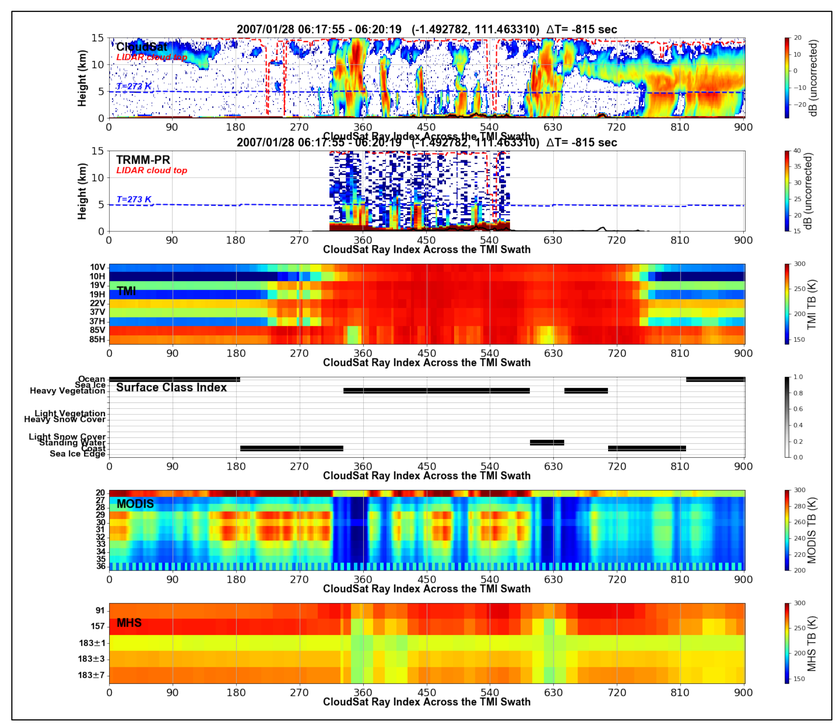




28 January 2007 0618 UTC
Orbits TRMM 52437 CloudSat 4003 NOAA-18 8711
Southeast Asia and Maritime Continent

The figure panels to the left show the TRMM overpass over Southeast Asia, an area that was recently investigated during the NASA Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP^{2}Ex), focused on airborne observations of the unique tropical meteorology and sources and types of aerosol conditions prevalent in this area. This ascending CloudSat overpass on this day passed over the Java Sea and central and west Kalimantan (1S 111E).

The figure panels to the right show the GMI data surrounding the GPM-CloudSat coincidence location, and corresponding 2-frequency radar profiles and traces of GMI, MHS and MODIS brightness temperatures, and illustrate the variable meteorology of this area. The presence of small scale (5-10 km horizontal scale) convective clouds at various stages of growth above and below the freezing level (5-km) are noted in the CloudSat cross section, with some cloud tops reaching 10-km or higher. DPR shows a coarser structure, and only show radar top echoes up to the freezing level. The 2B-GEOPROF-LIDAR data shows the top-most cloud layer is near 15-km across most of the cross section. This implies sensitivity to drop size and distribution, whose signature is In TMI data, the transition from water-land-water is obvious, but only the larger scale, more vertically developed clouds (near ray indices 360 and 630) are revealed only in the 85 GHz data. However MHS data with their expanded 157/183 GHz channel range, do pick up some of the smaller scale clouds near ray index 400. Thermal channels on MODIS (channel 31 is the longwave 11-um channel) are cold mostly everywhere there are cloud, with water vapor channels (27, 28) often as cold or colder over the tallest convection,



The work contained in this presentation was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with NASA.